JAMES & WELLS
INTELLECTUAL PROPERTY

FACSIMILE TRANSMISSION
From: +64 3 379 8220
To: +61 262 853 929

Total Pages: 31

18 April 2005
CHRISTCHURCH OFFICE

CONFIRMATION

Confirmation to follow

IP Australia
P O Box 200
Woden, ACT 2606
AUSTRALIA

Attention: Rajeev Deshmukh

Re: PCT Application No. PCT/NZ2003/00279
AgResearch Limited
MEASUREMENT APPARATUS AND METHOD
Our Ref: 42550/X288

Thank you for your second Written Opinion dated 14th March 2005.

Referring to that Opinion, and our conversation on the 14th April 2005:

The Examiner has stated that although all claims 1-15, 17-19 are novel, all the claims lack inventive step. We are somewhat surprised at this objection, given the Examiner's comments in the first Written Opinion that the subject matter of the former claim 5 was novel and inventive, which was subsequently added as an essential feature of claim 1. It thus appears the Examiner has reversed his conclusions from the first Written Opinion.

In the event any objections are maintained, we ask that the examiner identify the rational behind this inequitable reversal, particularly given the inevitable cost and inconvenience generated for the applicant by the need to respond to such inconsistent objections.

In any event, it is submitted the amended claims do possess inventive step over the prior art.

- Whilst the examiner states it is an obvious desideratum to place the emitter and/or detector adjacent to or in contact with the object this overlooks the practical considerations involved. If such a

CHRISTCHURCH OFFICE
Level II, PricewaterhouseCoopers Centre
119 Armagh Street
Christchurch
PHONE +64 3 379 3664
FAX +64 3 379 8220
EMAIL christchurch@jaws.co.nz
HOMEPAGE www.jaws.co.nz
POST PO Box 2201
Christchurch, New Zealand
DX WP20323, Christchurch

AUCKLAND OFFICE
PHONE +64 9 914 8740
FAX +64 9 914 8760
POST Private Bag 11907
Ellerslie, Auckland, New Zealand
DX CP34005, Auckland

HAMILTON OFFICE
PHONE +64 7 957 5660
FAX +64 7 957 5661
POST Private Bag 3140
Hamilton, New Zealand
DX GX10012, Hamilton

TAURANGA OFFICE
PHONE +64 7 578 4668
FAX +64 7 578 4001
POST PO Box 13365
Tauranga, New Zealand
DX HP40037, Tauranga

Patent and Trade Mark Attorneys
Barristers and Solicitors
IP/IT Specialists

capability had in fact been contemplated in the prior art documents, details of how the practical complications were addressed would be evident. However, no such description is present in any of the prior art, despite the high level of descriptive detail (as noted by the examiner) used for the various other system features.

- To achieve a configuration where the emitter (and optionally the detector) are positioned *immediately adjacent or in contact to the object,* requires either:

  1. precise placement of the object between static detectors and emitters (as per the prior art);

     Such a time consuming and exacting method is not compatible with high throughput applications such as meat packing plants, nor with accommodating objects of variable size and/or position between the emitter and detector.

  2. affixing the emitter and detectors to a rigid conduct or housing containing the object (e.g. grain, as disclosed in US 4311845, US 5871397, and GB 2359630);

     Although this provides a means of testing loose objects such as flour, grain and the like, the emitter cannot be said to be in direct contact with the actual object as per the present invention.

  3. providing a reversible drive apparatus to place at least the emitter on/immediately adjacent the object as per the present invention.

     Furthermore, unless the objects are presented to the measuring apparatus with a high degree of size and positional uniformity it is desirable to utilise some form of proximity sensor to ensure the emitter is accurately positioned in contact or immediately adjacent the object without impact.

     The prior art provides no suggestion of a proximity sensor means.

Thus, it is submitted that the prior art in fact teaches away from the concept of using a reversible drive apparatus. The availability of the citations dating back to 1978 illustrates that there has been ample opportunity for implementation of such a system should it have been obvious to those skilled in the art without the *ex-post facto* analysis warned of in case law.

Regarding the individual citations discussed by the examiner:

- WO 1991/02966: The examiner quotes page 20, lines 10-12, '*the sample container was positioned immediately above the transmitter horn*' (emphasis added). We submit however, that in

the context of the whole disclosure, it can be seen that passage refers to location of the sample in the horizontal axis and not its vertical proximity. This is evidenced by the corresponding passage on page 16, lines 11-12 which relates to the practical implementation (c.f. the coal conveyor belt application shown in figure 5) of the laboratory measurements described on page 20. It can be seen from figure 5 that the transmitter horn is placed under the conveyor belt and thus cannot be *immediately adjacent or in contact* with the object. Moreover, the citation discusses the issue of a variable thickness product (a conveyor belt of crushed coking and steaming coals) which could conceivably lend itself to the use of movable emitters and/or detectors. That there is no such suggestion supports the inventive step of the present invention.

- GB 2359630: The illustrations corresponding to the three applications of moisture measurements described are each schematic with respect to the physical interrelationship between system components. It is thus not clear if the emitter/detector shown in figure 1 are actually positioned on a cooked/baked product itself, or just a symbolic 'zone' through which the product would pass. The latter interpretation appears the most plausible given there is no reference to any means of moving the emitter/detectors and they appear to be fixed. Indeed page 4, line 2 states the horns are *"mounted on a stand"*, i.e. fixed. Consequently, is difficult to envisage a plurality of variably sized products such as baked goods passing through an exactly sized gap between an emitter and detector without interference.

- US 4131845: The introductory paragraph confirms the focus of the invention to moisture measurement of material *"confined to flow through a chute"*. The remaining description provides no alternative embodiments. Thus, there is no anticipation of the emitter/detectors being placed in contact with the product. Furthermore, given the ill-defined boundaries of such flow products (e.g. flour, grain and the like) and the consequential impracticality of attempting to position a movable emitter *immediately adjacent or in contact with* the flow, it is submitted the citation provides no teaching towards the present invention.

To further refine the inventive aspects of the present invention and in light of the examiner's comments, the claims have been further amended as shown on the **enclosed** tracked and clean copies including;

- deleting the reference to *'at least substantially'* in claim 1 and specifying that *'any emitted electromagnetic radiation from the emitter is transmitted into the object'*.

- amending claim 7 to be an independent claim incorporating all the integers of claim 1 plus original subject matter of claim 7, i.e. the addition of a proximity sensor.

- deleting claim 13. It is agreed the manual placement of the emitter and/or detector is incompatible with the addition of a drive

assembly as an essential integer of claim 1.

- replacing the subject of the former claim 16 with a dependant method claim stating the additional requirement that *'the apparatus is located and operable external to any enclosure or housing'.*

- amending the former claim 17 to include a dependency to the preceding apparatus claims, thus conferring the required novelty and inventive step.

- Corresponding claim renumbering, updating of relevant claim dependencies, and minor typographical corrections, have been performed. The corresponding portions of the description have also been updated and a copy of these pages is **enclosed**.

Yours sincerely
JAMES & WELLS

Andy Cable
Associate
andyc@jaws.co.nz

Enclosures:

Amended pages 8-10, 13, 14, 17-22 (tracked copy – including amendments made for first Written Opinion)
Amended pages 8-22 (clean copy)

referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided an apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector,

characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object such that any emitted electromagnetic radiation from the emitter is transmitted into the object, wherein to perform transmission/attenuation measurements, ~~the apparatus is configurable such that~~ said emitter is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object and said detector is positioned on an opposing side of the object such that the

detector ~~solely, or at least substantially~~ receives electromagnetic radiation transmitted through the object from the emitter

The present invention thus provides a means of mitigating measurement errors stemming from any detector readings of indirectly received electromagnetic radiation not passing though the object. This is particularly useful for temperature measurements, where the transmissivity of the object to the incident electromagnetic radiation varies according to temperature.

Thus, according to one embodiment of the present invention, said apparatus is configurable to perform temperature measurements by positioning of the emitter immediately adjacent or in contact with the surface of said object and positioning said detector on an opposing side of the object such that the detector ~~solely, or at least substantially~~ receives electromagnetic radiation transmitted through the object from the emitter.

In particular, the invention is suited to, but not restricted to, temperature measurements using microwave radiation.

According to one embodiment of the present invention there is provided an apparatus for measuring the temperature of an object, said apparatus including:

- a microwave emitter and a microwave detector

characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent to, or in contact with, a surface of the object, wherein to perform temperature measurements, said microwave emitter is positioned by said drive apparatus immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the microwave detector ~~solely, or at least substantially~~ receives microwave radiation transmitted through the object from the microwave emitter.

According to another aspect of the present invention there is provided a method of measuring the temperature of an object using microwave radiation using the apparatus as described above, said method characterised by the steps of:

- using said apparatus to positioning ~~a~~ the microwave emitter immediately adjacent or in contact with a surface of said object;
- positioning a microwave detector on an opposing side of the object to said emitter;

such that the microwave detector ~~solely, or at least substantially~~ receives microwave radiation transmitted through the object from the microwave emitter.

As used herein, the term object is to be interpreted widely and includes any substance, material, or organic matter, particularly those containing moisture and/or any other substance where the transmittivity of electromagnetic radiation energy changes measurably with temperature.

In one embodiment, said object is frozen, near frozen or chilled.

It will be appreciated however that the present invention is not necessarily limited to the temperature measurements of frozen or chilled objects. Alternative (non-temperature related) uses may be made of the measurements produced by the present invention.

~~Preferably, the present invention further includes drive apparatus capable of reversibly placing the said emitter immediately adjacent to, or in contact with, a surface of the object.~~

Optionally, the present invention also includes drive apparatus capable of reversibly placing the detector on an opposing side of said object to said emitter.

According to one aspect of the present invention, said drive apparatus is a linear

It is entirely feasible for an operator to manually place the emitter and detector on opposing sides of an object for a singular temperature measurement.

According to a further aspect, the present invention provides a method of measuring the transmission or attenuation of electromagnetic radiation through successive objects using the apparatus as hereinbefore described, comprising the steps;

- successively transporting objects via said conveyance system between the emitter and detector along the primary axis of travel;
- positioning the emitter adjacent to, or in contact with, each object when interposed between said emitter and detector;
- performing an electromagnetic radiation transmission or attenuation measurement;
- moving the emitter away from the object.

Preferably, the method further includes the steps of:

- positioning the detector adjacent to, or in contact with, each object when interposed between said emitter and detector prior to performing the electromagnetic radiation transmission or attenuation measurement;
- moving the detector away from the object.

According to one aspect, the apparatus is located and operable external to any enclosure or housing.

According to a further preferred embodiment, the present invention provides a method of measuring temperature of an object using microwave radiation using the apparatus substantially as described herein, said method characterised by the steps of:

- using said drive apparatus to position the microwave emitter immediately adjacent or in contact with a surface of said object;

- irradiating the object with microwave radiation from the emitter;

- detecting microwave radiation transmitted through the object with the microwave detector positioned on an opposing side of the object to said emitter

- calculating the object temperature from said microwave radiation received by the detector.

As previously stated, the inventive emitter and detector configuration may also be utilised with other forms of electromagnetic radiation and for non-temperature measurement purposes.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a first side elevation of a preferred embodiment of the present invention;

Figure 2 shows a second side elevation of the embodiment shown in figure 1;

Figure 3 shows an enlarged view of the embodiment shown in figure 1, and

Figure 4 shows an enlarged view of the embodiment shown in figure 2.

BEST MODES FOR CARRYING OUT THE INVENTION

Figures 1-4 show a first embodiment of the present invention for temperature measurement of frozen meat boxes in a meat processing plant.

In the embodiment shown, the microwave detector (3) is positioned a short distance below the carton (6) to allow for the passage of the conveyor system (5). It will be appreciated that in other embodiments, the detector (3) may be placed in contact with or immediately adjacent to the surface of the carton (6) to ensure no extraneous reflected or refracted microwaves are received by the detector (3). It has been found in practice however that separating the detector (3) from the surface of the object being the temperatures being measured (6) does not cause any appreciable degradation in the temperature measurement. Nevertheless, alternative detector/conveyor systems (3, 5) may be configured to permit placement of the detector (3) in contact with, or immediately adjacent to, the cartoon (6).

In yet further embodiments, the emitter (2) and detector (3) may be manually placed in position about the carton (6) to effect a single temperature measurement, as may be required for random sampling checks and the like.

Thus, by virtue of the aforementioned configuration, the present invention provides an apparatus and a method for measuring the transmission/attenuation of electromagnetic radiation transmitted through a sample without erroneous measurements from non-transmission radiation and without need to place the said objects in a measurement enclosure and without obstructing the throughput of objects in continuous production/packaging or storage applications.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

Claims:

1. An apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector,

   characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object such that any emitted electromagnetic radiation from the emitter is transmitted into the object, wherein to perform transmission/attenuation measurements, ~~the apparatus is configurable such that~~ said emitter is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object and said detector is positioned on an opposing side of the object such that the detector ~~solely, or at least substantially~~ receives electromagnetic radiation transmitted through the object from the emitter.

2. The apparatus as claimed in claim 1, wherein said apparatus is configurable to perform temperature measurements by positioning of the emitter immediately adjacent or in contact with the surface of said object and positioning said detector on an opposing side of the object such that the detector ~~solely, or at least substantially~~ receives any electromagnetic radiation transmitted through the object from the emitter.

3. The apparatus as claimed in claim 1 or claim 2, wherein said object includes any substance, material, or organic matter containing moisture and/or any other substance where the transmittivity of electromagnetic radiation energy changes measurably with temperature.

4. The apparatus as claimed in any one of the preceding claims, wherein said

object is frozen, near frozen or chilled.

~~5.The apparatus as claimed in any one of the preceding claims, further including drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object.~~

~~6.~~5. The apparatus as claimed in any one of claims ~~5~~1 - 4, wherein said drive apparatus is capable of reversibly placing the said microwave detector on an opposing side of said object to said emitter.

~~7.~~6. The apparatus as claimed in any one of claims ~~5~~ 1 - ~~6~~5, wherein said drive apparatus is a pneumatic, hydraulic, or electro-mechanical operated linear actuator.

~~8.~~7. An apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector, characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object such that any emitted electromagnetic radiation from the emitter is transmitted into the object, ~~The apparatus as claimed in any one of claims 5 - 7, wherein the drive apparatus/emitter assembly further includes~~and a proximity sensor capable of determining the proximity of the object to the emitter, wherein to perform transmission/attenuation measurements, said emitter is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object and said detector is positioned on an opposing side of the object such that the detector receives electromagnetic radiation transmitted through the object from the emitter.

~~9.~~8. The apparatus as claimed in claim ~~8~~7, wherein the proximity sensor is an ultrasonic sensor.

~~10.~~9. The apparatus as claimed in any one of the preceding claims, wherein said detector is positionable immediately adjacent to, or in contact with, said object.

~~11.~~10. The apparatus as claimed in any one of claims 1-~~9~~8, wherein said detector is located proximate to, but not in contact with said object.

~~12.~~11. The apparatus as claimed in any one of the preceding claims, further including a moving conveyance configured to transport a plurality of objects along a primary axis of travel passing between the emitter and detector.

~~13.~~12. The apparatus as claimed in claim ~~12~~11, wherein the moving conveyance includes conveyor systems, pallet-handling systems, automated cargo transport systems, robotic, manual or human-operated object handling and/or transportation systems.

~~14. The apparatus as claimed in any one of claims 1-4, wherein the microwave emitter and detector are manually positionable on opposing sides of an object for temperature measurement.~~

~~15.~~13. A method of measuring the transmission or attenuation of electromagnetic radiation through successive objects using the apparatus claimed in claim ~~12~~ 11 or ~~13~~12, comprising the steps;

- successively transporting objects via said conveyance system between the emitter and detector along the primary axis of travel;
- positioning the emitter adjacent to, or in contact with, each object when interposed between said emitter and detector;
- performing an electromagnetic radiation transmission or attenuation measurement;

- moving the emitter away from the object.

~~16.~~14. The method as claimed in claim ~~15~~ 13 including the further steps of;

- positioning the detector adjacent to, or in contact with, each object when interposed between said emitter and detector prior to performing the electromagnetic radiation transmission or attenuation measurement;

- moving the detector away from the object.

~~17.~~15. The method as claimed in claims 13 or 14, wherein the apparatus is located and operable external to any enclosure or housing. ~~An apparatus for measuring the temperature of an object, said apparatus including:~~

~~-a microwave emitter and a microwave detector;~~

~~characterised in that to perform temperature measurements, said microwave emitter is positionable immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the microwave detector solely, or at least substantially receives microwave radiation transmitted through the object from the microwave emitter.~~

~~18.~~16. A method of measuring temperature of an object using microwave radiation using the apparatus as claimed in claims 1-12, said method characterised by the steps of:

- using said drive apparatus to positioning ~~a~~ the microwave emitter immediately adjacent or in contact with a surface of said object;

- irradiating the object with microwave radiation from the emitter;

- ~~positioning a~~detecting microwave radiation transmitted through the object with the microwave detector positioned on an opposing side

of the object to said emitter ~~such that microwave detector solely, or at least substantially receives microwave radiation transmitted through the object from the microwave emitter.~~

- calculating the object temperature from said microwave radiation received by the detector.

~~19.~~17. An apparatus substantially as hereinbefore described with reference to, and as shown in the drawings.

~~20.~~18. A method substantially as hereinbefore described with reference to, and as shown in the drawings.

Abstract

An apparatus (1) for measuring the transmission or attenuation of electromagnetic radiation through an object (6), said apparatus (1) including an electromagnetic radiation emitter (2) and detector (3),

characterised in that the apparatus (1) further includes a drive apparatus capable of reversibly placing the said emitter (2) immediately adjacent or in contact with a surface of the object (6) such that any emitted electromagnetic radiation from the emitter (2) is transmitted into the object, wherein to perform transmission/attenuation measurements, ~~the apparatus in configurable such that~~ said emitter (2) is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object (6) and said detector (3) is positioned on an opposing side of the object (6) such that the detector (3) ~~solely, or at least substantially~~ receives electromagnetic radiation transmitted through the object (6) from the emitter (2).

referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided an apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector,

characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object such that any emitted electromagnetic radiation from the emitter is transmitted into the object, wherein to perform transmission/attenuation measurements, said emitter is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object and said detector is positioned on an opposing side of the object such that the detector receives electromagnetic

radiation transmitted through the object from the emitter

The present invention thus provides a means of mitigating measurement errors stemming from any detector readings of indirectly received electromagnetic radiation not passing though the object. This is particularly useful for temperature measurements, where the transmissivity of the object to the incident electromagnetic radiation varies according to temperature.

Thus, according to one embodiment of the present invention, said apparatus is configurable to perform temperature measurements by positioning of the emitter immediately adjacent or in contact with the surface of said object and positioning said detector on an opposing side of the object such that the detector receives electromagnetic radiation transmitted through the object from the emitter.

In particular, the invention is suited to, but not restricted to, temperature measurements using microwave radiation.

According to one embodiment of the present invention there is provided an apparatus for measuring the temperature of an object, said apparatus including:

- a microwave emitter and a microwave detector

characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent to, or in contact with, a surface of the object, wherein to perform temperature measurements, said microwave emitter is positioned by said drive apparatus immediately adjacent the surface of said object and said detector is positioned on an opposing side of the object such that the microwave detector receives microwave radiation transmitted through the object from the microwave emitter.

According to another aspect of the present invention there is provided a method of measuring the temperature of an object using microwave radiation using the

apparatus as described above, said method characterised by the steps of:

- using said apparatus to position the microwave emitter immediately adjacent or in contact with a surface of said object;

- positioning a microwave detector on an opposing side of the object to said emitter;

such that the microwave detector receives microwave radiation transmitted through the object from the microwave emitter.

As used herein, the term object is to be interpreted widely and includes any substance, material, or organic matter, particularly those containing moisture and/or any other substance where the transmittivity of electromagnetic radiation energy changes measurably with temperature.

In one embodiment, said object is frozen, near frozen or chilled.

It will be appreciated however that the present invention is not necessarily limited to the temperature measurements of frozen or chilled objects. Alternative (non-temperature related) uses may be made of the measurements produced by the present invention.

Optionally, the present invention also includes drive apparatus capable of reversibly placing the detector on an opposing side of said object to said emitter.

According to one aspect of the present invention, said drive apparatus is a linear actuator including, but not limited to, pneumatic, hydraulic, electro-mechanical operated actuators.

The drive apparatus/emitter assembly may further include a proximity sensor capable of determining the proximity of the object to the emitter. Thus, the emitter may be reliably and repeatably placed at the same degree of proximity to each object without

risk of impact. In one embodiment, the proximity sensor is an ultrasonic sensor.

Preferably, said detector is positioned immediately adjacent to or in contact with said object. However, in an alternative embodiment, said detector is located proximate to, but not in contact with said object.

The present invention as described above confers a number of advantages over the prior art. There is no restriction on the object size due to the need to place the object in an enclosure. Furthermore, the possible detection of erroneous electromagnetic radiation not transmitted through the object is practically eliminated by placing the transmitter adjacent the object surface. Placing the detector (as well as the emitter) immediately adjacent or in contact with the object also aids in ensuring only microwaves transmitted through the object (or at least substantially only these microwaves) are detected. Surprisingly, it has been found that locating the detector at a short distance from the object does not necessarily corrupt accurate measurements.

The present invention is also ideally suited to rapid repeat temperature measurements of objects on a production line or the like. As there is no requirement for placing the object in a housing or enclosure, the dwell-time between measurements is not exacerbated by removing the objects from a conveyor system or the like, placing in an enclosure for measurement, and (possibly) replacing on the conveyor system. Instead, the temperature of chilled or frozen objects may be measured directly on a conveyor or similar, thus speeding throughput significantly.

Thus, according to a further embodiment, said object is placed on a moving conveyance located between the emitter and detector.

A moving conveyance includes, but is not limited to, conveyor systems, pallet handling systems, automated cargo transport systems, robotic, manual or other human operated object handling and transportation systems and the like.

Preferably, said conveyance has a primary axis of travel.

According to one aspect of the present invention, said drive apparatus is a linear actuator operating substantially orthogonally to said primary axis of the conveyance.

In embodiments using objects of highly uniform size and positioning on the conveyance means, it may be possible for the conveyance means to transport the object immediately adjacent to the emitter without the need to move the emitter, i.e., eliminating the need for an actuator.

Thus, temperature measurements of successive objects may be provided by the combined operation of said conveyance system moving successive objects along said primary axis of travel between the emitter and detector and a said linear actuator moving the emitter (and optionally) the detector into and out of contact with an object when interposed between said emitter and detector.

It is thus also possible to scan a large object by making repeated temperature measurements at different points or even continuous measurements as the emitter/detector is moved over the surface of the object.

However, it will be appreciated that the present invention need not necessarily be used in automated or multi object measurement application. The advantages of both simplified equipment over other electronic non-invasive systems together with the improved accuracy, convenience and non-invasive characteristics compared to drilled core samples favour the present invention for any scale of operation/application.

It is entirely feasible for an operator to manually place the emitter and detector on opposing sides of an object for a singular temperature measurement.

According to a further aspect, the present invention provides a method of measuring the transmission or attenuation of electromagnetic radiation through successive objects using the apparatus as hereinbefore described, comprising the steps;

- successively transporting objects via said conveyance system between the emitter and detector along the primary axis of travel;

- positioning the emitter adjacent to, or in contact with, each object when interposed between said emitter and detector;

- performing an electromagnetic radiation transmission or attenuation measurement;

- moving the emitter away from the object.

Preferably, the method further includes the steps of:

- positioning the detector adjacent to, or in contact with, each object when interposed between said emitter and detector prior to performing the electromagnetic radiation transmission or attenuation measurement;

- moving the detector away from the object.

According to one aspect, the apparatus is located and operable external to any enclosure or housing.

According to a further preferred embodiment, the present invention provides a method of measuring temperature of an object using microwave radiation using the apparatus substantially as described herein, said method characterised by the steps of:

- using said drive apparatus to position the microwave emitter immediately adjacent or in contact with a surface of said object;

- irradiating the object with microwave radiation from the emitter;

- detecting microwave radiation transmitted through the object with the microwave detector positioned on an opposing side of the object to said emitter

- calculating the object temperature from said microwave radiation received by the detector.

As previously stated, the inventive emitter and detector configuration may also be utilised with other forms of electromagnetic radiation and for non-temperature measurement purposes.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a first side elevation of a preferred embodiment of the present invention;

Figure 2 shows a second side elevation of the embodiment shown in figure 1;

Figure 3 shows an enlarged view of the embodiment shown in figure 1; and

Figure 4 shows an enlarged view of the embodiment shown in figure 2.

BEST MODES FOR CARRYING OUT THE INVENTION

Figures 1-4 show a first embodiment of the present invention for temperature measurement of frozen meat boxes in a meat processing plant.

Figures 1 and 2 show an embodiment of the present invention in the form of a microwave temperature measurement apparatus (1), comprised of a microwave emitter (2), a microwave detector (3), support frame (4) and a moving conveyance system in the form of conveyor system (5). This embodiment is primarily configured for measuring the temperature of frozen meat placed in standard meat cartons (6). However, the temperature measurement of alternative organic produce such as

cheese, fish or poultry may also be performed. Testing by the applicant has determined the successful functioning of the present invention with each such produce.

Furthermore, the use of microwave radiation is exemplary and is not limiting. Alternative forms of electromagnetic radiation may be employed according to the specific requirements of the application without departing from the inventive configuration of the emitter and detector described herein.

Figures 3 and 4 show enlarged representations of the microwave emitter and detector (2, 3), conveyor assembly (5) and carton (6). The microwave emitter (2) is located at the lower end of a drive apparatus in the form of a vertically orientated linear actuator (7) whilst the microwave detector (3) is fixed below the conveyor system (5) in a confronting relationship directly below the microwave emitter/actuator assembly (2, 7).

The microwave detector (3) and the exterior housing of the actuator (7) are secured to the support frame (4). The conveyor system (5) is formed from a plurality of cylindrical rollers (8) located transversely across the width of the conveyor (5). Meat cartons (6) are driven along the conveyor (5) either actively or under the influence of gravity by inclining the conveyor (5).

The primary axis of travel of the cartons (6) along the conveyor (5) passes between the microwave emitter and detector (2, 3) at which point a stop cylinder (9) raises from below the plane of the conveyor (5) surface to restrain the carton (6) while a temperature measurement is taken. A nudge bar (10) positions each carton laterally to align with the emitter/detector (2, 3) to account for any variation in alignment as cartons are transported on the conveyor (5).

When the carton (6) is correctly positioned by the stop cylinder (9) and nudge bar (10) between the microwave emitter and detector (2, 3) respectively, the linear

actuator (7) lowers the emitter (2) to a position immediately adjacent the surface of the carton (6). The position of the emitter (2) with respect to the carton (6) is governed by an ultrasonic proximity sensor (not shown). Thus, the emitter (2) may be rapidly and repeatably placed in the same proximity to each successive carton (6) without risk of impact or the need for manual intervention. Alternative proximity, contact or position sensors may be utilized instead of an ultrasonic sensor.

The microwave emitter (2) is then activated and a pulse of microwaves (not shown) is transmitted through the carton (6) towards the detector (3). The degree of attenuation of the transmitted microwave beam provides an indication of the temperature of the carton (6) and its contents, i.e. the frozen meat.

As the emitter is placed directly on the surface of the carton, virtually all the microwaves emitted have to travel through the carton (6) before being either absorbed, or detected by the detector (3). This configuration reduces the possibility for any external reflection, refraction or other indirect routes from the emitter (2) to the detector (3).

Although the above embodiment shows the use of temperature measurements with a standard sized meat container, it will be appreciated that a variety of other objects/containers may be employed by configuring and dimensioning the present invention (1) accordingly. It will be further appreciated that alternative conveyance means to the conveyor system (5) may be employed.

In the embodiment shown, the microwave detector (3) is positioned a short distance below the carton (6) to allow for the passage of the conveyor system (5). It will be appreciated that in other embodiments, the detector (3) may be placed in contact with or immediately adjacent to the surface of the carton (6) to ensure no extraneous reflected or refracted microwaves are received by the detector (3). It has been found in practice however that separating the detector (3) from the surface of the object

being the temperatures being measured (6) does not cause any appreciable degradation in the temperature measurement. Nevertheless, alternative detector/conveyor systems (3, 5) may be configured to permit placement of the detector (3) in contact with, or immediately adjacent to, the carton (6).

In yet further embodiments, the emitter (2) and detector (3) may be manually placed in position about the carton (6) to effect a single temperature measurement, as may be required for random sampling checks and the like.

Thus, by virtue of the aforementioned configuration, the present invention provides an apparatus and a method for measuring the transmission/attenuation of electromagnetic radiation transmitted through a sample without erroneous measurements from non-transmission radiation and without need to place the said objects in a measurement enclosure and without obstructing the throughput of objects in continuous production/packaging or storage applications.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

Claims:

2. An apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector,

   characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object such that any emitted electromagnetic radiation from the emitter is transmitted into the object, wherein to perform transmission/attenuation measurements, said emitter is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object and said detector is positioned on an opposing side of the object such that the detector receives electromagnetic radiation transmitted through the object from the emitter.

3. The apparatus as claimed in claim 1, wherein said apparatus is configurable to perform temperature measurements by positioning of the emitter immediately adjacent or in contact with the surface of said object and positioning said detector on an opposing side of the object such that the detector receives any electromagnetic radiation transmitted through the object from the emitter.

4. The apparatus as claimed in claim 1 or claim 2, wherein said object includes any substance, material, or organic matter containing moisture and/or any other substance where the transmittivity of electromagnetic radiation energy changes measurably with temperature.

5. The apparatus as claimed in any one of the preceding claims, wherein said object is frozen, near frozen or chilled.

6. The apparatus as claimed in any one of claims 1 - 4, wherein said drive apparatus is capable of reversibly placing the said microwave detector on an opposing side of said object to said emitter.

7. The apparatus as claimed in any one of claims 1 - 5, wherein said drive apparatus is a pneumatic, hydraulic, or electro-mechanical operated linear actuator.

8. An apparatus for measuring the transmission or attenuation of electromagnetic radiation through an object, said apparatus including an electromagnetic radiation emitter and detector, characterised in that the apparatus further includes a drive apparatus capable of reversibly placing the said emitter immediately adjacent or in contact with a surface of the object such that any emitted electromagnetic radiation from the emitter is transmitted into the object, and a proximity sensor capable of determining the proximity of the object to the emitter, wherein to perform transmission/attenuation measurements, said emitter is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object and said detector is positioned on an opposing side of the object such that the detector receives electromagnetic radiation transmitted through the object from the emitter.

9. The apparatus as claimed in claim 7, wherein the proximity sensor is an ultrasonic sensor.

10. The apparatus as claimed in any one of the preceding claims, wherein said detector is positionable immediately adjacent to, or in contact with, said object.

11. The apparatus as claimed in any one of claims 1-8, wherein said detector is located proximate to, but not in contact with said object.

12. The apparatus as claimed in any one of the preceding claims, further including

a moving conveyance configured to transport a plurality of objects along a primary axis of travel passing between the emitter and detector.

13. The apparatus as claimed in claim 11, wherein the moving conveyance includes conveyor systems, pallet-handling systems, automated cargo transport systems, robotic, manual or human-operated object handling and/or transportation systems.

14. A method of measuring the transmission or attenuation of electromagnetic radiation through successive objects using the apparatus claimed in claim 11 or 12, comprising the steps;

- successively transporting objects via said conveyance system between the emitter and detector along the primary axis of travel;
- positioning the emitter adjacent to, or in contact with, each object when interposed between said emitter and detector;
- performing an electromagnetic radiation transmission or attenuation measurement;
- moving the emitter away from the object.

15. The method as claimed in claim 13 including the further steps of;

- positioning the detector adjacent to, or in contact with, each object when interposed between said emitter and detector prior to performing the electromagnetic radiation transmission or attenuation measurement;
- moving the detector away from the object.

16. The method as claimed in claims 13 or 14, wherein the apparatus is located and operable external to any enclosure or housing.

17. A method of measuring temperature of an object using microwave radiation using the apparatus as claimed in claims 1-12, said method characterised by the steps of:

- using said drive apparatus to position the microwave emitter immediately adjacent or in contact with a surface of said object;
- irradiating the object with microwave radiation from the emitter;
- detecting microwave radiation transmitted through the object with the microwave detector positioned on an opposing side of the object to said emitter
- calculating the object temperature from said microwave radiation received by the detector.

18. An apparatus substantially as hereinbefore described with reference to, and as shown in the drawings.

19. A method substantially as hereinbefore described with reference to, and as shown in the drawings.

Abstract

An apparatus (1) for measuring the transmission or attenuation of electromagnetic radiation through an object (6), said apparatus (1) including an electromagnetic radiation emitter (2) and detector (3),

characterised in that the apparatus (1) further includes a drive apparatus capable of reversibly placing the said emitter (2) immediately adjacent or in contact with a surface of the object (6) such that any emitted electromagnetic radiation from the emitter (2) is transmitted into the object, wherein to perform transmission/attenuation measurements, said emitter (2) is positioned by said drive apparatus immediately adjacent or in contact with the surface of said object (6) and said detector (3) is positioned on an opposing side of the object (6) such that the detector (3) receives electromagnetic radiation transmitted through the object (6) from the emitter (2).